Development of an Improved Ignition Train for the 120mm Tank Ammunition Primer

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Tank Ammo Primers

120mm Tank Ammo uses 3 electric primer designs:

M123A1 Primer

- Base-pad ignition system
- Used on M829A3 APFSDS-T

M129 Primer

- Short bayonet style
- Used on M830A1 HEAT-MP-T

Thickwall Primer

- Replaces the old M125
- Long bayonet style
- Used on M865 & M831A1 training rds.

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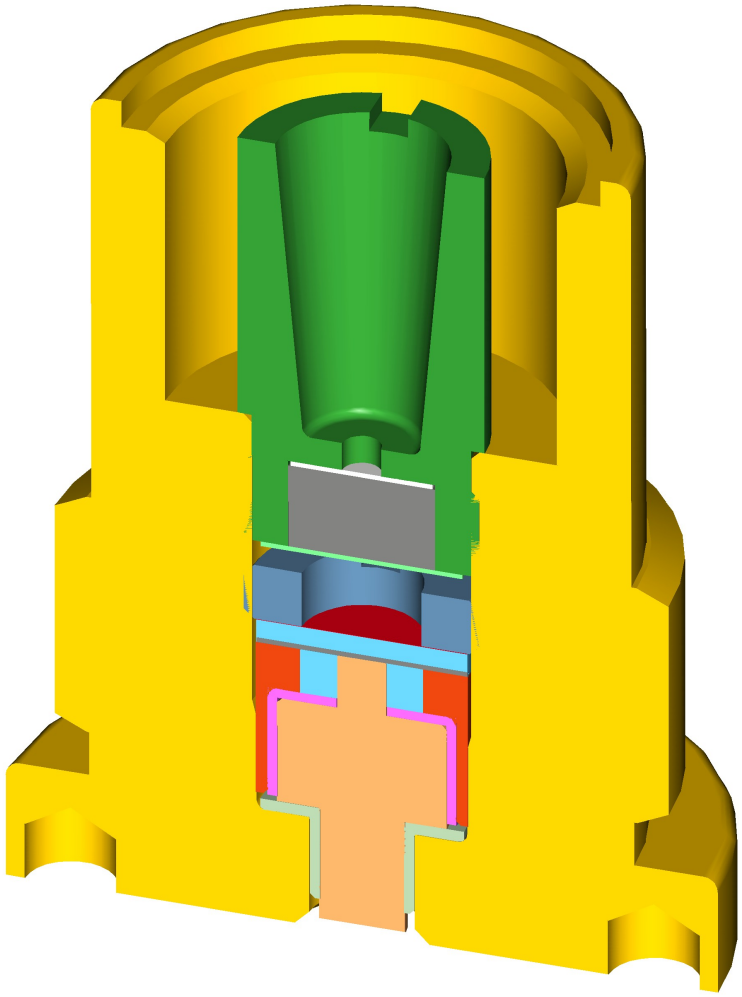
Common Ignition Train



All three 120mm primers share a common ignition train…

- Brass Electrode
- Polyamide Insulators
- Ignition Cup
- Dual Bridge-wire
- Ignition Charge, 2.56 grains
  - 43.8% Potassium Chlorate
  - 34.9% Lead Thiocyanate
  - 19.7% Charcoal
- Retainer (except M123A1)
- Closing Plug Assy. (except M123A1)
  - 3 grains Black Powder

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Problems

… and a common set of problems:

- Primer is 1940’s technology
- Many critical defects (13 for primer as a whole)
- Hazardous igniter mix (Lead compounds, low auto-ignition temperature)
- Difficult materials to procure (gum arabic, gum tragacanth, animal glue, lead thiocyanate, black powder)
- Low no-fire current (0.2 amps, safety issue)
- Not HERO safe (safety issue)
- Suspect in many failures

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Contract

The government/contractor team is investigating primer design alternatives:

- Phase 1 work was completed in 2003
  - GD-OTS designed 1-piece primer body and investigated materials for the body
  - ATK developed and tested 2 improved ignition train designs
- Phase 2 will be performed in 2004
  - ARDEC to test ignition trains for HERO and PESD compliance
  - GD-OTS to test 3 candidate materials, and develop plastic liner with ARDEC
  - ATK to down-select to single ignition train design and continue its development

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Ignition Train Objectives

The Phase 1 ignition train objectives were:

- Evaluate new technologies
- Evaluate new energetic materials
- Reduce number of components and joints
- Reduce number of critical defects
- Enhance producability and reliability
- Meet 1-amp 1-watt 5-min no-fire
- Meet EMF / HERO requirements
- Consider cost in design process

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Teaming

Kilgore Flares Co. (KFC)

- Updated hot bridgewire design
- Current primer supplier to ATK

Ensign-Bickford Aerospace & Defense (EBA&D)

- Semiconductor bridge (SCB) design

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- Direction and coordination

Kilgore Development

Kilgore developed an updated hot bridgewire ignition train:

- Evaluated Igniter Mixes
  - Lead Thiocyanate based (baseline)
  - Titanium Dichromate
  - Zirconium Potassium Perchlorate
- Evaluated Booster Charge
  - Black Powder, Class 7 (baseline)
  - Boron Potassium Perchlorate ($BKNO^3$)
- Developed Metal Parts & Procedures
  - Weld technique
  - Vent hole size
  - Disc thickness

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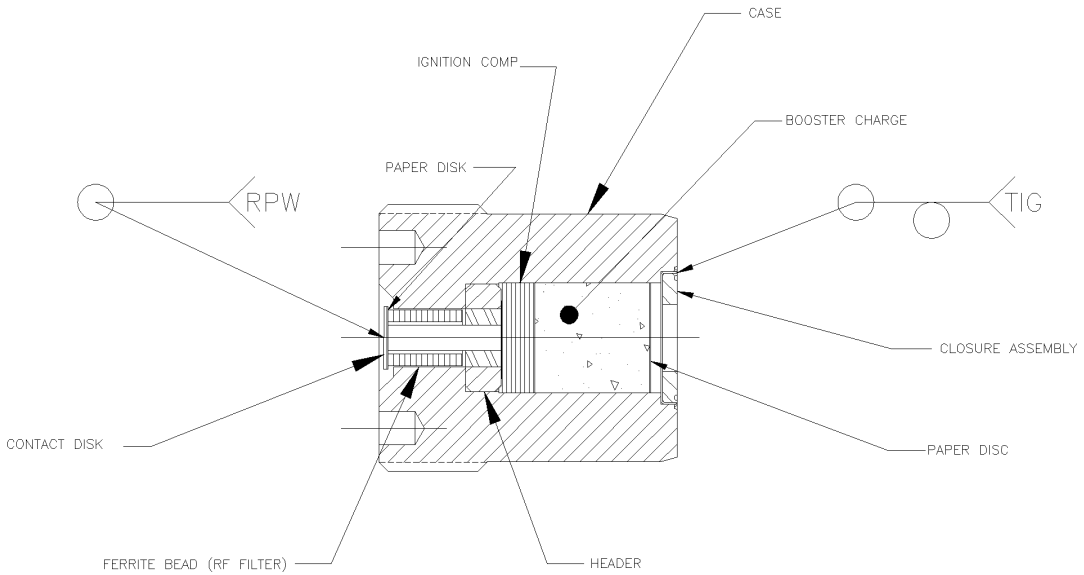
Kilgore Design

Kilgore's design features:

- Flush welded bridgewire
- Glass-metal header
- 100 mg ZPP igniter comp
- 350 mg BKNO3 booster
- Fair-Rite RF Filter
- Stainless steel case
- Fewer parts
- Cheaper to make



Ensign-Bickford Design

Ensign-Bickford developed an SCB ignition train:

- Semiconductor bridge
  - Faster
  - HERO safe
  - Consistent
- Glass-steel header
  - 10 mg ZPC igniter mix
  - 195 mg ZPP booster
- Hermetically sealed assy.
  - Laser welded cup

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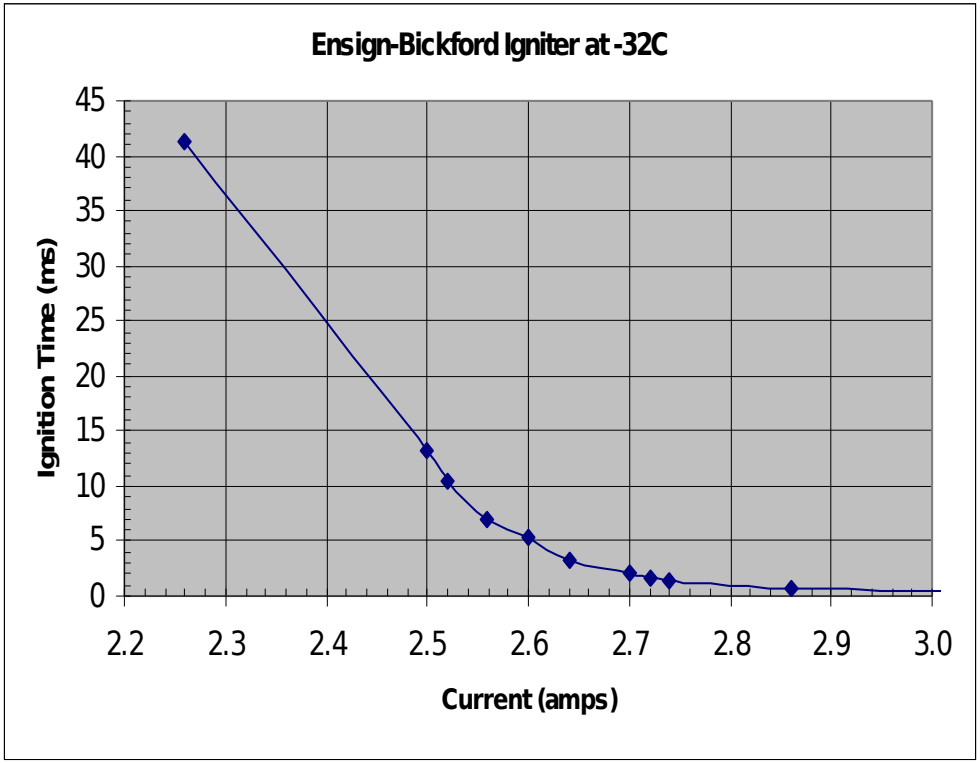
SCB Features

SCB advertised features:

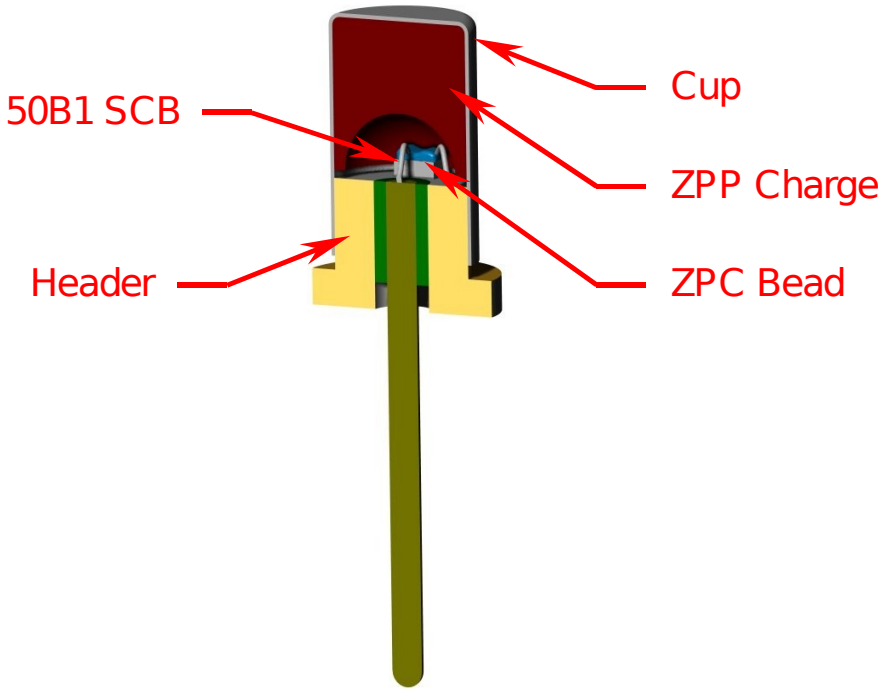
- Very good no-fire due to heat sinking of silicone
- Very low all-fire due to consistency of photolithographic process
- Emits plasma jet (8500◦F)
- Function times measured in microseconds
- High degree of RF insensitivity
- Designed to meet HERO requirements



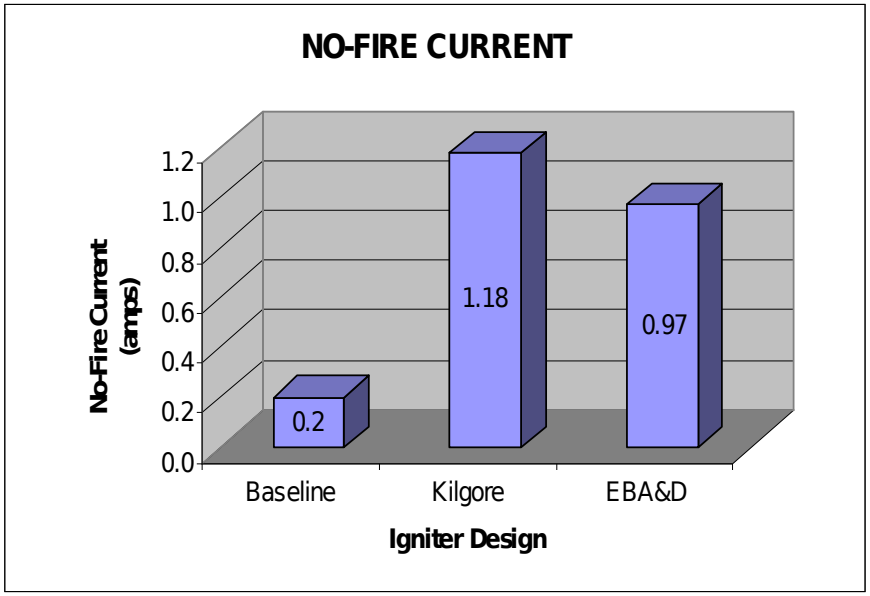
Ensign-Bickford Development

Ensign-Bickford development included:

- Tested 2 SCB Designs
  - 50B1
  - 52B2
- Evaluated “Bead” Mixes
  - Lead Salt
  - Zirconium Potassium Chlorate
- Selected Booster Charge
  - Zirconium Potassium Perchlorate
- Mounted in modified Head Loading Assy.
  - Schedule & budget limitations



No-Fire Current



Higher is better

No-fire currents were raised:

- Objective: improve safety by raising no-fire current (less sensitive)
- Goal: 1-amp 1-watt 5-minute no-fire
- Baseline: 0.2-amps 18-sec
- Criteria: 99.9% Reliability, 95% confidence
- Both experimental designs were near goal

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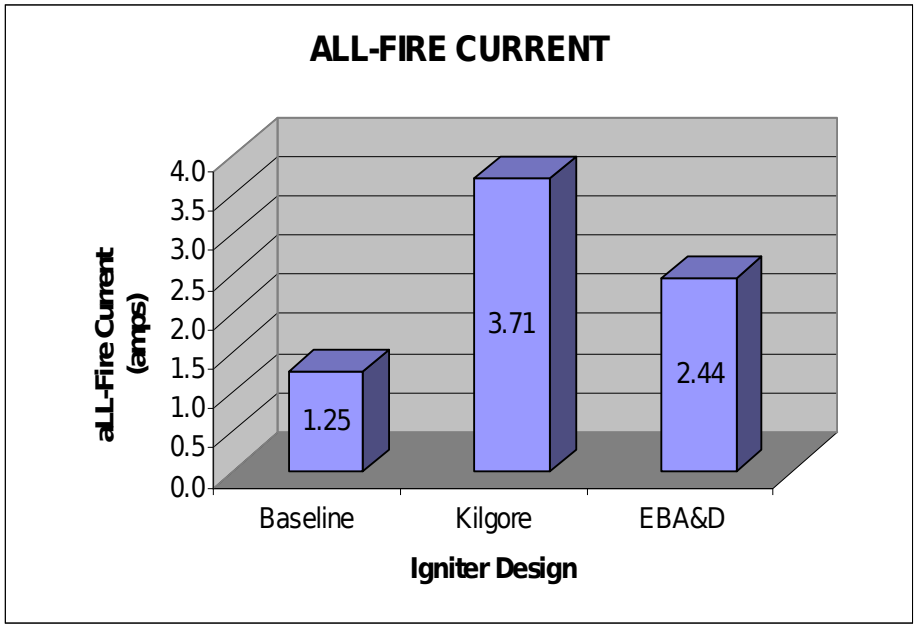
All-Fire Current



Lower is better

All-fire currents increased:

- Objective: Minimize all-fire current for firing reliability
- Tank firing circuit 5-amps+
- Baseline all-fire 1.25 amps
- Criteria: 99.9% Reliability, 95% confidence
- Kilgore all-fire highest but acceptable
- Ensign-Bickford all-fire lower due to consistency of SCB

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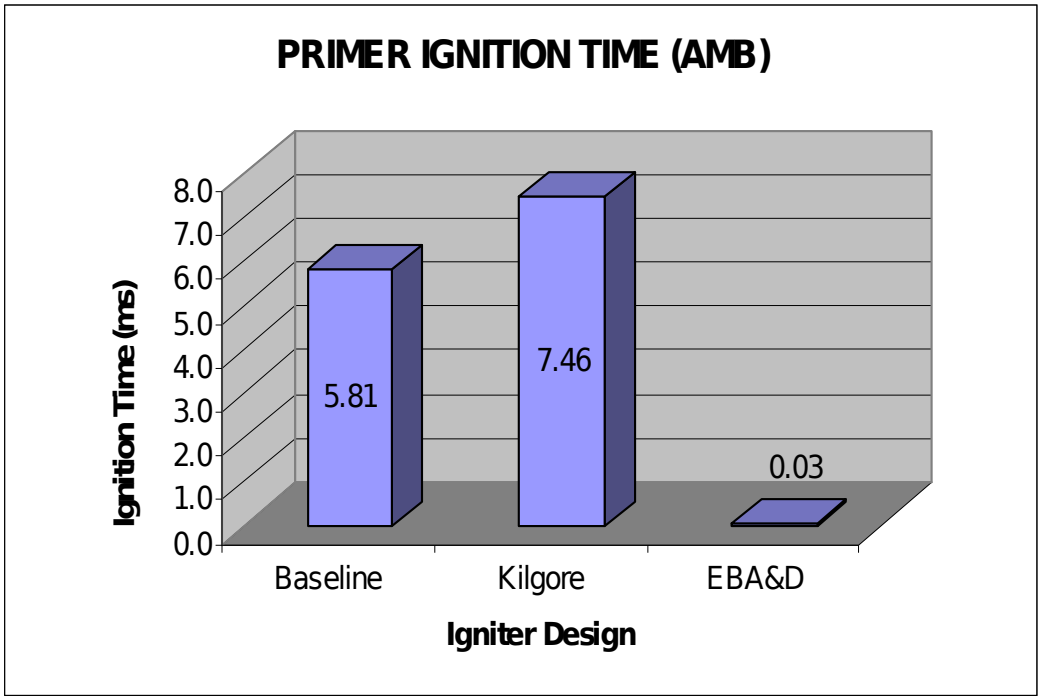
Primer Level Test

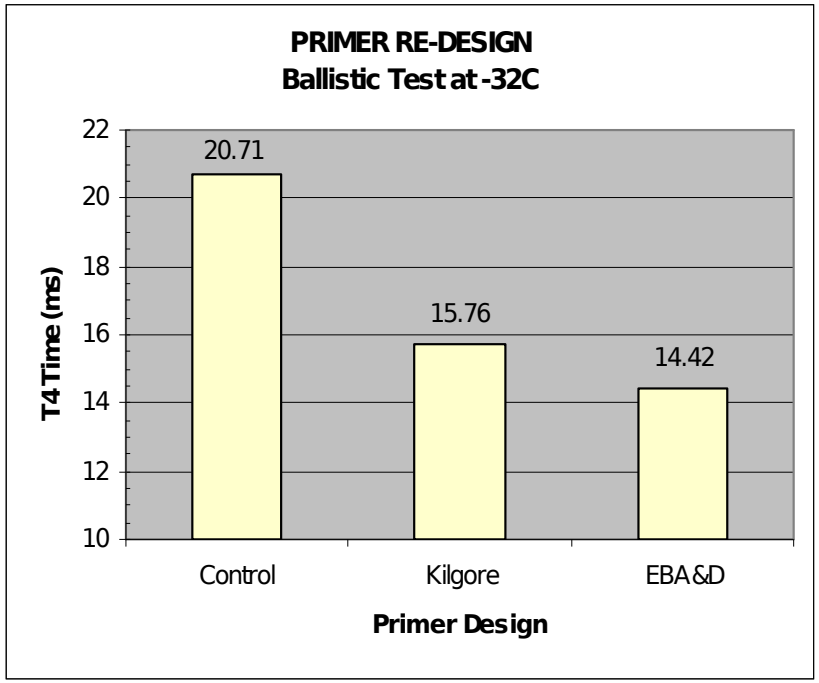
SCB Primer stole the show during primer static test:

- Direct comparison test
- 5 at each of 3 temps
- 3.5 amps firing current
- Fired alternately
- Ensign-Bickford design very fast
- Kilgore design slow



Lower is better

Cartridge Level Test



Lower is better

Both designs looked good in cartridge test:

- Loaded in M865 cartridges
- Gun test at Socorro NM
- 5.0 amp firing circuit
- 5 each at cold (-32C)
- EBA&D design fastest
  - 6.3 ms faster than baseline
- Kilgore design nearly as fast
  - 5.0 ms faster than baseline
- Higher firing current explains variance from static results

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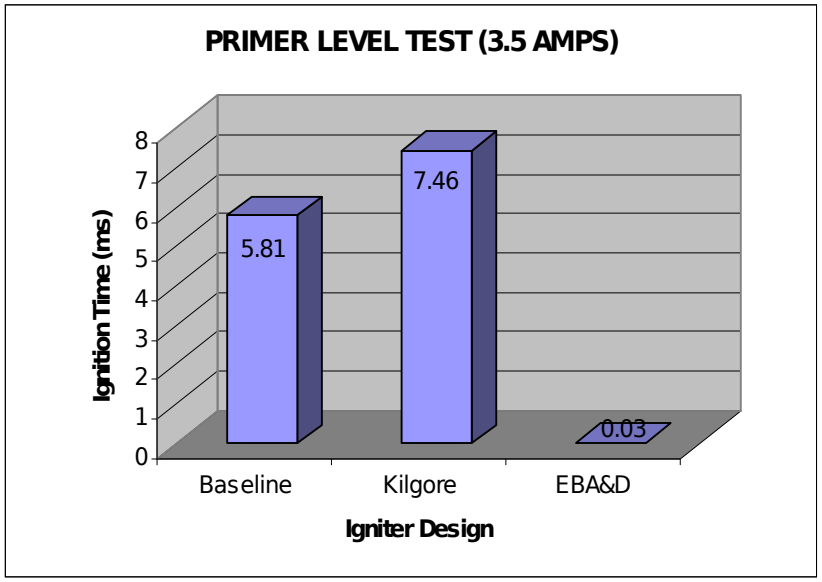
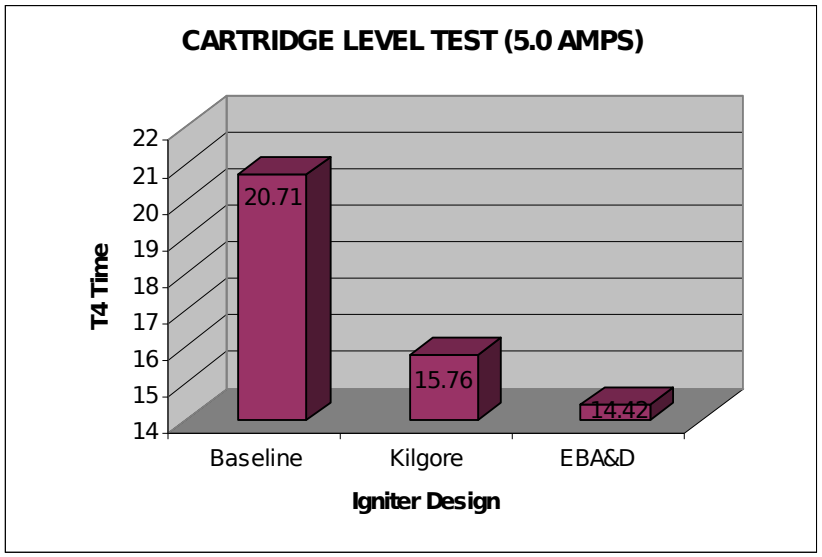
What Happened?





Firing current affects comparison:

- Primer level test fired at 3.5 amps
- Cartridge level test fired at 5.0 amps
- Kilgore's igniter performance improves significantly between 3.5 and 5.0 amps
- Ensign-Bickford's igniter performance changes little in this range

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Conclusions

- Two improved primer ignition train designs have been demonstrated
  - Welded bridgewire
  - SCB
- Both designs are viable candidates
  - Both meet the objectives
  - Both improve cartridge T4 time
- Additional tests planned before downselect
  - HERO
  - PESD
- Final design will be further developed and tested in Phase 2
  - Phase 2 to begin in 2004

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